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Determinants of Variability in U.S. Rice Production Costs

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Abstract

This report identifies possible sources of cost variation among U.S. rice producers and determines which common farm organizational and operator characteristics are statistically associated with costs of production. The main findings are:

(1) Most of the variation is explained by factors outside of the operator's control, such as weather, quality of land and other resources, and shifts of input prices.

(2) Significant determinants of per-unit production costs were capitalization costs (percent total depreciation claimed in 1992 relative to total production value), land tenure (percent of rice share-rented and percent of rice cash-rented), water management efficiency, and grain moisture level at harvest.

(3) Of all variables, capitalization costs relative to production value, land tenure, water application efficiency, and grain moisture level at harvest had the greatest influence on per-unit cost variation, accounting for 94 percent of total variance effects on a national level.

(4) In the Arkansas non-Delta, capitalization costs, both land tenure variables, and moisture level at harvest were positively related to costs, while only capitalization costs and moisture level at harvest were significant variables in California. In the Mississippi River Delta, capitalization costs, land share-rented, specialization, and water efficiency were positively related to per-unit costs. In the Gulf Coast, specialization and capitalization levels were positive significant variables.

Keywords: U.S. rice farms, rice regions, costs of production, cost distribution, cost variation, variance effects.

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Introduction

Rice, a major U.S. food grain, ranks consistently in the top 25 commodities (crops and livestock) by cash receipts. Rice production was valued at $1.7 billion, just over 1 percent of total U.S. crop receipts, in 1997 (the most recent data available). In two States, Arkansas and Louisiana, however, rice ranks in the top 5 commodities and averages over 10 percent of each State's total agricultural product. Rice is also important for U.S. balance of trade and is of particular interest to policymakers since nearly 50 percent of the crop is exported. Since 1986, farm legislation has provided rice marketing loans for U.S. farmers to guarantee competitive export prices as international prices rise and fall.

USDA surveyed rice growers for the 1992 crop year in the Agricultural Resource Management Study (ARMS), formerly called the Farm Costs and Returns Survey, which collects information on the production systems used to grow rice and on the costs associated with the crop. From this survey, costs and returns for producing rice can be estimated and analyses can be performed relating to the determinants of these costs. The 1992 ARMS survey data included 9,722 rice farms and 99 percent of planted acres as measured by the National Agricultural and Statistics Service (NASS).

Rice is a particularly important crop to analyze as Federal legislation changes because of its unique combination of recently legislated planting flexibility, high participation in past Government programs, and traditional participation in a highly-competitive export market.

Rice is grown on land that is usually unsuitable for most alternative crops but that is suitable for the flood irrigation used with rice. This is particularly true in California where there are few alternatives to rice production in the counties where rice is concentrated. In other rice-producing States, such as Arkansas, Mississippi, and Louisiana, rice is raised in rotation with soybeans. In these States, soybeans are often double-cropped with wheat and feed grains. In some cases, cotton is also grown. In Texas, grazing and livestock production are options. With few other alternative crops in some regions and with rice prices strongly influenced by supply and demand conditions in Asia, rice farmers historically depended on Government programs to keep rice a viable component of their crop mix. Now that supply control programs were eliminated in 1996, what will happen to those operations? For example, Texas landlords who have historically rented much of the rice land to farmers are considering renting their land for other production.

This report examines the factors behind the costs of producing rice in 1992. The goal is to:

• determine the cost structure of the rice enterprise on farms producing rice,

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- identify how the cost structure of the rice enterprise differs from other key commodities grown in rice-producing regions,

- identify key factors determining differences in the cost structure of rice production.

Results of the 1988 crop survey are presented in an earlier report by Salassi. At that time, farmers were responding to the provisions of the 1985 Farm Bill, which required participation in acreage control programs in return for receiving benefits from a rice marketing loan program. This report covers the 1992 survey (under the 1990 Farm Bill) and makes some comparisons with the 1988 survey results. However, the 1990 Farm Bill was generally a continuation of the 1985 Bill. Therefore, any changes are likely still related to the 1985 Bill. Another survey is being planned for rice around 2001, which should begin to show the effect of the sharply different 1996 Farm Bill. With three surveys spanning dramatic changes in farm legislation from 1985 through 1996 and beyond, it will be possible to track structural changes and adjustments as Government policy changed. In this report as in the earlier report by Salassi, producers were grouped on the basis of variable cash production expenses, enterprise size, and production region.

Analytical Approach and Methodology: The 1992 Survey

The production costs for each farm in the survey were calculated by ERS's farm-level budget generator using the farm-level production cost and input data from the rice ARMS. From this basic cost structure the farms were compared by the determinants of the variability in the costs between regions, cost levels, and enterprise size. This is consistent with the earlier analysis of 1988 rice growers, permitting direct comparisons of the two surveys.

In addition, we developed an "operator account" for each 1992 survey observation (see pages 10-11), hypothesized a set of rice farm organization and operator characteristics, and tested these characteristics for significance as sources of cost variation.

Characteristics expected to be a major influence on rice production costs are listed below. Some are particular to rice, while others are based on previous studies of other field crops (McBride, AIS-54; Ali and Brooks).

Land Use and Rotation--Crop rotation controls weeds, particularly the red rice weed, and helps control some plant diseases. Recommended rotation programs (Mullins et al.) suggest that rice be planted 1 year out of 3, although rotations with rice planted 1 year out of 2 are also common. The necessity of crop rotation limits the land available for rice each year.

Crop rotation maximizes profit based on relative returns with soybeans, soybean-wheat double cropping, and to a lesser degree feed grains (corn and sorghum). Rotation is a best management practice (bmp) to deal with red rice. However, herbicide-resistant rice varieties in the early stages of development would eliminate the need to rotate crops because of the limitations of red rice.

Rice farms in the Arkansas non-Delta and Mississippi River Delta areas were the most diversified farms, producing several crops, primarily soybeans, wheat, and cotton, in addition to rice. Soybeans were the crop most often rotated with rice. Rice was usually planted 1 year in 3. When soybeans were planted, they were frequently doubled-cropped with wheat. Cotton produced on rice farms, primarily in the Mississippi River Delta, was usually grown on the same land year after year and was not rotated with rice.

Soybeans were also rotated with rice in southwest Louisiana and, to some extent, in Texas. Many farms in these areas also left sizable portions of their land idle, either as pasture or fallow, rather than planting a different crop because the 1992 rice program, under the ARP and the 50/85 provisions, provided incentives to farmers to idle rice land. Farms in California reported planting some acreages to other crops, but rice was the dominant crop enterprise on these farms. With few alternatives for the land planted to rice and an absence of red rice infestations, farmers had little incentive to rotate their rice lands in California.

Land Tenure--Most of the land on rice farms in 1992 was rented, most often with share rent. The portion of total acreage share-rented ranged from approximately 19 percent in the upper Texas Coast to nearly 70 percent in southwest Louisiana.

Under typical share-rental arrangements, the landlord receives a share of the value of production and a share of any Government payments received in exchange for paying a portion (typically one-fourth to one-third) of the production expenses. The most common production expenses paid by landlords included seed, fertilizer, chemicals, drying, irrigation fuel, and ownership costs of irrigation equipment.

Cash-rented land ranged from 11 percent in the Arkansas non-Delta to 67 percent in the upper Texas Coast. Owned land ranged from 18 percent in southwest Louisiana to 59 percent in California.

Irrigation--Unlike most field crops, rice is grown in flooded fields. The land is flooded at or just after planting, and the flood is typically maintained through much of the growing season until the field is drained just prior to harvest.

The chief sources of water are onfarm wells, onfarm reservoirs, or other surface sources. Farmers also purchase water from canal companies or irrigation districts that deliver water to the farm via an irrigation canal or ditch. Secondary sources such as runoff water collected in a reuse reservoir, referred to as tail-water recovery, supplement primary sources.

Water from onfarm wells was the dominant source of irrigation water for rice farms in the Arkansas non-Delta and Mississippi River Delta and, to a lesser extent, in southwest Louisiana and the lower Texas Gulf Coast. Surface irrigation water (nonpurchased) from onfarm sources was most prevalent in southwest Louisiana. Purchased irrigation water was a major irrigation source in California and Texas.

Farms that relied on farm wells reported an average of about two wells per farm dedicated to irrigation. Well depth varied greatly, with the shallowest wells located in the Arkansas non-Delta and Mississippi River Delta areas and the deepest wells located in Texas. The average well diameter exceeded 10 inches, with the largest wells being in California and Texas.

Well sources of water require a pump capable of lifting the water out of the well and onto the field. Farms using surface water (purchased or nonpurchased) usually delivered the water to the field by way of canals or ditches and, in some cases, did not use pumps. California and the upper Texas Gulf Coast regions, where water delivery via canals is popular, averaged less than one pump per farm. The average size of pump, in gallons per minute (G.P.M.), varied considerably among areas.

Diesel motors were the most common type of power unit used to operate rice irrigation pumps in the Arkansas non-Delta, Mississippi River Delta, and the upper and lower Texas Gulf Coasts. The average size of irrigation motors, in horsepower, depended on the source of water, as well as the distance from the water to the surface, as much larger motors were required to pump irrigation water from underground wells than to pump water onto fields from surface water sources.

Effects of Government Programs on Rice Production

Throughout the 1980's and the first half of the 1990's, Government programs played a dominant role in the profitability of growing rice in the United States. The United States is a major rice exporter (usually ranking in the top three) on the world market due to the consistent availability of high-quality rice. Since the United States is a relatively high-cost rice-producing country, Government programs have helped ensure a steady supply at competitive prices by providing income support to producers. Participation of rice producers in the rice program was always high (usually well over 90 percent). This dependence of virtually the entire U.S. rice industry on Government support, the rules for participation (such as acreage reduction programs), and the location of base acreage prior to the beginning of the 1980's and the supply-control programs of that era influenced the efficiency and location of rice production.

Acreage reduction programs (ARP's) reduce the efficiency of input use and spread fixed costs over fewer acres. Areas with the largest base acreage typically had an advantage over other areas with less base acreage but lower costs. Continued high Government support reduced the shift of acreage to cheaper areas. As Government income support shrinks and rules for participation change, the location and methods of producing rice are likely to change as well. In addition, new policy related to resource use and conservation will also have an effect on production practices. The use of irrigation on all U.S. rice production makes production costs especially vulnerable to changes in fuel and electricity prices for running irrigation pumps, availability and costs of obtaining sufficient water for irrigation, costs of avoiding pollution of communal water sources, and efficient use of available water. As a result, no-till practices have increased in popularity since 1992. Results of the next survey should provide interesting detail on the growth of no-till (Schnepf and Just).

Regional Differences and Fertilizer and Chemical Use

Comparing 1992 rice farms in the Arkansas non-Delta, California, Mississippi River Delta, and Gulf Coast (Texas and southwest Louisiana) areas revealed differences in cost structure that could influence production shifts and other changes that might occur under the flexibility provision established in the 1996 Farm Bill. Average acres planted to rice ranged from 290 acres in the Arkansas non-Delta area to 386 acres along the Gulf Coast (table 1). Total farm size, however, differed more, with Mississippi River Delta (MRD) farms about 50 percent larger than Arkansas or California farms. These large farms were more diversified, with soybeans, cotton, and wheat the most common crops.

California rice farms realized yields over 50 percent higher than farms in other regions. Nearly all rice grown in California is medium-grain, which averages higher yields than Southern long- or medium-grain rice. Also, rice diseases are less of a threat in California--the climate is drier and

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Changing Conditions in U.S. Rice Regions

Since 1985, rice has gradually shifted out of the Gulf Coast (mainly Texas) to more cost-efficient areas of the Delta States and non-Delta Arkansas. Although California's rice acreage declined in the 1980's, California rice is highly regarded in the growing domestic market. Acreage jumped sharply in 1994 when Japan entered the world market and purchased 2.3 million tons of rice (including 500,000 tons of California rice). The implementation of the Uruguay General Agreement on Tariffs and Trade (UR-GATT) minimum access requirements for Japan and South Korea portend further planting incentives for California producers of japonica rice beginning in 1995 and expanding through 2000. However, droughts, water regulation, and strict air and water pollution controls will likely limit growth.

The Mississippi River Delta, and particularly Mississippi, are the cheapest locations for growing U.S. rice. Mississippi has a large, relatively inexpensive land base that is generally flatter than other rice-growing regions. The flatter contour of the land pairs easily with technology that lowers cost over time (laser leveling and use of fewer levies to efficiently move water over the fields). Water is readily available and relatively cheap because there is not a local population competing for the water supply or powerful enough to strongly protest nearby use of agricultural chemicals. Other industries, such as cotton and catfish (a heavy user of water), compete for water.

California and the Gulf Coast rice-growing regions are confronting severe water and environmental constraints. Barring major technological breakthroughs, the severity of these constraints is likely to worsen with time, threatening the regions' ability to produce rice competitively.

Costs of rice production are above average in the Gulf Coast, but are the highest in Texas. There are four principal factors (Schnepf and Just) generating Texas' high costs of production:

(1) few feasible alternative crops to rotate with rice, thus preventing the spread of fixed costs across enterprises;

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cooler, weather is less variable, and no red rice grows. Higher yields and occasionally higher prices help boost value of production to greater levels than in the South.

The 1988 survey showed less variability among regions in terms of farm size. The average rice acreage was about 10 percent less than in 1992 and about the same across regions. The 1988 farms also tended to be smaller in terms of farm sales, probably reflecting lower commodity prices in 1987. Average yields were about 2 percent less in 1988 than in 1992.

Nitrogen is applied at relatively heavy levels in all regions (table 1). For other fertilizer nutrients, however, California and the Gulf Coast report higher use than other regions. Fewer acres are treated with herbicides in California in favor of aerial seeding and burning of rice stubble, but insecticide use is higher than in other regions. The high degree of aerial seeding in California and the Gulf Coast (mostly Louisiana) makes those areas more vulnerable to water weevils.

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(2) abbreviated time periods for critical field operations due to weather;

(3) above-average pest-management problems, including weeds, insects, and diseases, resulting in higher costs than in other States; and

(4) higher-than-average water pumping and distribution costs as well as increasing municipal, industrial, and recreational competition for scarce resources.

Costs in southwest Louisiana are generally lower than in Texas because of the availability of relatively cheap surface water for irrigation.

Above-average costs of production in California are due to high variable costs and significantly above-average costs for general farm overhead, taxes, and insurance. In addition to high production costs, California rice growers face the most stringent air and water pollution controls in the Nation. Four important problems (Schnepf and Just) confront the economic viability and expansion of California's rice industry:

(1) competition with urban users for an increasingly scarce water supply;

(2) water quality issues, particularly concerning pesticide runoff;

(3) restrictions imposed on the burning of rice straw to control pests; and

(4) urban growth overtaking farmland.

Higher water-user costs and increased regulatory pressures concerning pesticide runoff and straw burning are likely to further raise the costs of California rice production. Rapid urban growth directly converts rice land to urban uses. Indirectly, urban growth puts competing demands on water and increases the need for greater regulation on aerial application of pesticides as well as the level of pesticide runoff from irrigation water.

(From *Background for 1995 Legislation*, p. 22.)

Cost Groups

The average variable cash expense of producing the 1992 U.S. rice crop was $316.05 per planted acre. Cost estimates for each surveyed farm were converted to a cost per cwt by using actual farm-level yields reported in the ARMS (fig. 1). Costs per cwt, rather than per acre, were used as the basis for segmenting the distribution because of regional differences in yields. Rice farms were divided into three groups according to the level of variable cash expenses: low-, mid-, and high-cost (table 2). The average variable cost per cwt for all farms was $5.39. Costs per cwt for low-cost producers averaged $3.68 per cwt, for mid-cost producers $5.43, and for high-cost producers $8.29 per cwt.

Twenty-five percent of rice farms surveyed had variable cash expenses of $4.32 per cwt or lower (compared with $4.67 in 1988). These low-cost producers accounted for 32 percent of total rice production. High-cost producers had variable cash expenses of more than $6.66 per cwt (compared with $6.59 in 1988), accounting for 25 percent of rice farms and 18 percent of total rice production. The remaining farms fell in between the high- and low-cost farms and accounted for the other 50 percent of rice produced.

Nearly 40 percent of high-cost operations were in the Gulf Coast region of Louisiana and Texas while over 40 percent of low-cost operations were in the non-Delta region of Arkansas (table 3). Total acres operated were essentially unchanged among cost groups but the acres planted to rice were nearly 50 percent higher in the low-cost group, implying that higher specialization to rice results in lower per-unit cost. Among inputs, more high-cost producers applied phosphorus and potassium and applied them at higher rates.

Since the cost distributions are on a per-unit-of-output basis, yield can be a major factor in whether a farm is classified low- or high-cost. Each group expected about the same yield and their planting decisions would have been affected by these expectations. Mid- and high-cost growers had lower yields than expected. Low-cost producers reported the highest yields (62.6 cwt), the greatest rice acreage (393 acres on average per farm), and the highest percent of rice acreage (31 percent). High-cost producers reported the lowest rice yields (52.8 cwt), the smallest rice acreage (263 acres per farm), and the lowest percent rice acreage (23 percent).

The 1988 survey reflected a period of severe financial stress among U.S. farmers and ranchers. High-cost rice growers in the earlier survey were much more likely to have high debt levels (40 percent were classified as financially vulnerable or marginally solvent) than in 1992 (20 percent in high-debt financial position).

Characteristics of Low- and High-Cost Farms

Landownership--More than 50 percent of the rice acreage of low-cost farms was owned while about 33 percent was cash-rented. High-cost farms owned about 43 percent of their rice acreage and share-rented an average of 41 percent.

Acreage abandoned--About 11 percent of rice acreage on high-cost farms was abandoned after incurring some production expenses.

Fertilizer usage--Producers on low-cost farms applied about 137 pounds of nitrogen per acre on average while those on high-cost farms applied 149 pounds of nitrogen per acre. Low-cost farms also applied less phosphorus and potash and, as a result, fertilizer expense was about 50 percent higher for high-cost farms (table 3).

Chemical usage--There was little difference between chemical use for high-cost and low-cost farms.

Fuel expense--Fuel use and expense per acre were about two times higher for high-cost farms.

Labor--High-cost rice farms reported 2.5 times higher hired labor costs than low-cost farms.

Farm Size and Production Characteristics

Rice farms vary greatly in size, with the largest often assumed to be the most cost effective. The rice sample was subset into four general acreage classes: less than 120 acres planted to rice, 120-249 acres, 250-499 acres, and 500 or more rice acres. Thirty-seven percent of the surveyed farms had 250-499 acres, representing about 40 percent of both total U.S. rice acres and total U.S. rice production (table 4). These farms were mostly in the Arkansas non-Delta region and were the most dependent on rice for agricultural sales. Half of these farms were in the small- to mid-commercial sales class (between $50,000 and $250,000 annual farm sales).

The size of the rice enterprise had little effect on input use or farm characteristics. While the larger operations contributed more to total U.S. rice production, the yields among size groups were not significantly different, averaging about 59 cwt. Chemical and fertilizer application rates and seeding rates were also very similar across acres. There was a noticeable difference, however, in fuel use--farms with 500 or more acres used 36 gallons per acre while the smallest farms, less than 120 acres, used 47 gallons per acre. As one might expect, efficiency in mechanization increased as enterprise size increased.

From a financial perspective, one would expect larger farms to be more financially well off as reflected by the financial position of the whole farm. The survey, however, revealed that about the same percent of farms in each size group (62 percent) were classified as financially favorable, with positive net farm income and a debt/asset ratio of .40 or less. Some difference did show up in the marginal solvency category with positive income and higher debt, where larger farms had a higher percentage of operations (17 percent) and a smaller percentage of farms (18 percent) had negative income and low debt. This implies that the larger operations can carry a higher debt level and still realize positive incomes.

Comparing the 1988 and 1992 survey data highlights how financial conditions had improved by 1992. Even the smallest acreage class, less than 120 rice acres per farm, shows a significant drop in farms financially classified as high debt since 1988. However, the largest size class, 500 acres or more, shows the opposite, with an increase in high-debt farms in 1992.

Data from the ARMS are also used to identify possible sources of cost variation among U.S. rice producers (table 5). Regression analysis is used to determine which, if any, common farm organizational and operator characteristics are statistically associated with costs of production. To measure the extent that each characteristic influences production costs, the sample variation of production costs per cwt of rice is separated into the portion attributable to each characteristic; t-tests are performed to measure statistical significance. Information about the influence of these variables on costs of production may provide insight about which farm operators and management practices are associated with lower per-unit production costs.

The Operator Budget--To study cost variation, the 1992 production costs are estimated for farm operators, rather than for the sector as published annually by the USDA. Farm operator estimates (McBride, AIS-53) differ from sector estimates by excluding both landlord shares of costs and returns and the economic costs of owned inputs. The distinction between operator and landlord costs allows us to examine the relationship of farm organization and operator characteristics with

costs of production. Likewise, economic costs (or opportunity costs) of owned inputs are excluded so that the implications of farm resource tenure and financial condition can be explored.

Farm operator estimates include cash and noncash production costs. Cash costs are divided into variable and fixed components. Variable input costs for rice, excluding any landlord contributions, are reported directly by farm operators in the ARMS. Fixed cash costs, including property taxes, insurance, interest, and other overhead costs, are estimated by allocating whole-farm expenditures reported by each operator according to the total value of farm production. Land rental cost is the actual expenditure for cash-rented rice acreage. Property taxes are charged only on owned acreage planted to rice.

Noncash costs include whole-farm depreciation expenses, allocated to rice according to the value of rice production, and the value of noncash benefits provided for hired labor (housing, meals, etc.), allocated to rice by each farm operator.

To control for variations in yield resulting from factors beyond the farm operator's control (primarily weather), per cwt rice production costs are expressed using the expected yield that farm operators reported in the survey. The expected yield reported by producers in the ARMS was used as the basis for initial production and input use decisions. Expressing costs per unit of expected yield reduces the effects of weather, pests, and other uncontrollable events that occur during the growing season on unit production costs. Expected yield also indicates the planned yield of each farmer given the unique resource capabilities of individual farm operations and the selected input mix.

Because costs include only the portion paid by farm operators, expected yield on share-rented acreage includes only the portion expected by the farm operator. Farm operator costs per acre are divided by the expected yield to find the costs per cwt that were expected, or planned for, on each farm operation.

Model Specification--Farm organizational characteristics are possible factors affecting per unit production costs among U.S. rice growers (table 5). Previous studies of corn and barley helped identify an initial set of characteristics that were tested as explanatory variables (McBride, AIS-54; Ali). Additional variables relating to irrigation and drying were expected to be important to rice while not necessarily important to corn or barley. The other set of variables used in the regression were size of the rice enterprise, degree of specialization in rice production, rotation scheme, financial condition, type of land tenure, water use efficiency, and moisture level at harvest.

The size of a rice enterprise, as measured by acres planted with rice, is expected to be inversely related to costs of production. Larger farms typically have lower unit costs because costs of fixed inputs, such as machinery and equipment, can be spread over more units of output. Since the relationship between size and cost is not expected to be linear, alternative forms are examined to find whether quadratic or reciprocal best describes the relationship.

Specialization in rice production is measured by the percentage of a farm's total value of production that is contributed by rice. A negative relationship would suggest the expectation that

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operators of more specialized farms would, due to larger investment and more time involved, develop better managerial skills for growing a specific commodity than more diversified operators and be more aware of cost-saving techniques. However, previous analysis has shown that low-cost rice producers often plant greater amounts of other crops as well as more rice, suggesting a lack of alternative crops for high-cost producers.

Rotation schemes can be defined several ways. Recommended rotation practices for producers in the southern States limit rice planting to 1 out of every 3 years to control for red rice, although rotations with rice planted 1 year in 2 are becoming more common as programs to reduce rice acreage diminish. California producers, however, are generally able to grow rice continuously because of their zero incidence of red rice. Our rotation variable tests the significance of continuously growing rice over the 3-year period (1990-1992) versus using a rotation scheme, with mixed results espected. In some cases, we expect costs to be positively related to continuous cropping as yields are reduced because of the build-up of red rice. In other cases, an inverse relationship between costs and no rotation scheme (lower costs with continuous cropping) may be more indicative of regional, managerial, or land resource differences associated with higher yields.

The effects of farms' financial conditions are also examined. Previous analysis has shown that rice farming has high investment costs, in large part because it requires expensive, specialized equipment. We chose a variable to measure degree of capitalization by showing total farm depreciation claimed in 1992 for all capital assets relative to total farm production value. This representative, financial variable is expected to be positive relative to unit production costs.

The two land tenure variables are percentage of acreage cash-rented and percentage share-rented. These variables could be positive or negative depending on the relative costs of land ownership and rental.

Water use efficiency is measured in inches of irrigation water applied per cwt of rice produced and is expected to be positively related to per cwt costs. Water management efficiency is improved by changing management practices, adopting new technology, and upgrading current equipment and land formation procedures to further conserve water.

Rice is usually harvested at 18-23 percent moisture to achieve the best milling yield, but must be dried to 12-13 percent for safe storage. Damaging the kernels during the drying process is relatively easy because rapid drying can cause fissures or cracks that can dramatically affect the milling quality of the grain. Most harvested rice is dried before it is sold. Green, or undried, rice may be sold at a discount if the grain cannot be immediately milled. Rice drying costs, whether custom-dried or dried on-farm, are directly related to the moisture amount that must be removed from the grain so that it can be safely stored. A variable showing the grain moisture percentage level at harvest measures potential drying costs or possible market price discounts if the grain is sold green.

Farm operator characteristics are represented by level of education of the farm operator. Education is expected to be negatively related to unit production costs. Education was measured using binary variables for each of three groups:

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(1) operators not graduating from high school;
(2) operators completing high school, but not college; and,
(3) operators completing college.

Groups 2 and 3 are tested individually against group 1 to determine if higher education contributes to lower production costs.

Sources of Variation in Production Costs

Farm organization characteristics

- Rice acres planted
- Rice acres squared
- Land tenure (cash or share rented)
- Crop rotation

- Water efficiency
- Specialization
- Capitalization and debt
- Harvest moisture level

Farm operator characteristics

- Education

The farm organization variables that had the greatest influence on variations in per-hundredweight production costs were:

- Capitalization and debt
- Share rent
- Harvest moisture level

Results

The relationship between per cwt costs of production and farm organizational and operator variables is estimated for a sample of U.S. rice growers (table 5). The estimated coefficients describe the change in unit production costs from a change in each of the organizational and operator variables. The t-statistics indicate which of the estimated coefficients are statistically different from zero.

The R^2 result of .38 demonstrates that most of the variation is explained by other factors outside of the operator's control, such as weather, quality of land and other resources, and shifts in input prices. Several of these factors have a strong effect on yields and thus on per-unit costs.

Among farm organizational and operator characteristics tested on a national level, only five of the variables in the model were statistically significant at the 95-percent confidence level or higher. While one might expect the level of specialization in rice to be negatively related to production costs, rice acres and the ratio of rice's value of production to total farm value of production were not significant. Crop rotation, which is strongly recommended by rice extension agents, and farmers' education level also were not significant in the model. What did turn out to be significant determinants of per-unit production costs were capitalization costs (percent total depreciation claimed in 1992 relative to total production value), land tenure (percent of rice acreage share-rented and percent of rice cash-rented), water management efficiency, and grain moisture level at harvest. All the statistically-significant variables were positively related to per-unit costs, as expected.

Results varied by region. In the Arkansas non-Delta, capitalization costs, both land tenure variables, and moisture level at harvest were positively related to costs, while only capitalization costs and moisture level at harvest were significant variables in California. In the Mississippi River Delta, capitalization costs, land share-rented, specialization, and water efficiency were positively related to per cwt costs, and operators who were high school graduates with some or no college were found to have lower production costs than those with less than a high school education. In the Gulf Coast, specialization and capitalization levels were positive significant variables, and producers who grew rice continuously over the 1990-92 period had lower per-unit costs than those who did not plant rice every year, contrary to expectations. Perhaps this result shows that low-cost producers were more likely to have found ways to productively grow rice continuously.

Size was not a significant variable but, as expected, was negatively related to per unit production costs. Tests on alternative forms of the cost-size relationship found them to be quadratic. Over the range of operation sizes in the ARMS data, farm operator costs tend to decline with size.

Variance in cost can be broken down and attributed to different explanatory variables (table 5). The total effects that a single variable has on cost variation may then be determined relative to other variables.

Of all variables, capitalization costs relative to production value, land tenure, water application efficiency, and grain moisture level at harvest had the greatest influence on per-unit cost variation, accounting for 94 percent of total variance effects on a national level.

Capitalization costs relative to production value was the most influential variable, responsible for 75 percent of the variation. On a regional level, capitalization costs, land tenure, and water application efficiency explained most of the cost variation in the Mississippi River Delta. Capitalization costs, land tenure, and moisture level of grain at harvest explained most of the cost variation in the Arkansas non-Delta. Capitalization costs and moisture level of grain at harvest explained over 80 percent of the cost variation in California.

Conclusions

The presumed goal of a business is to maximize profit. While this analysis does not directly measure profit, which is a whole-farm concept, it does approximate the profit of the rice enterprise by measuring the net returns to rice over both cash and economic costs. The low-cost 25 percent of rice farms in 1992 had average net returns over cash expenses (excluding direct Government payments) of $115.54 per planted acre compared with minus $11.34 and minus $179.45 for mid- and high-cost farms, respectively.

The distribution of low-cost rice farms among the four major regions is very similar to the U.S. average for all rice farms. There was a slightly higher representation of farms from the Arkansas non-Delta region, implying more efficient production in this, the major rice-growing region of the United States. The efficiency of this region also implies that rice growers there could be better able to adjust to changes over time. The mid-cost 50 percent of rice farms had a similar regional distribution.

More significant is the number of Gulf Coast farms who are in the high-cost group. These farms are currently having difficulty renting land, have very high water costs, and have the highest percent of farms classified as financially vulnerable. Gulf Coast farms will be most susceptible to financial stress, should it occur, and most dependent on Government support.

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Figure 1

Distribution of rice variable cash expenses, 1992

Dollars per hundredweight
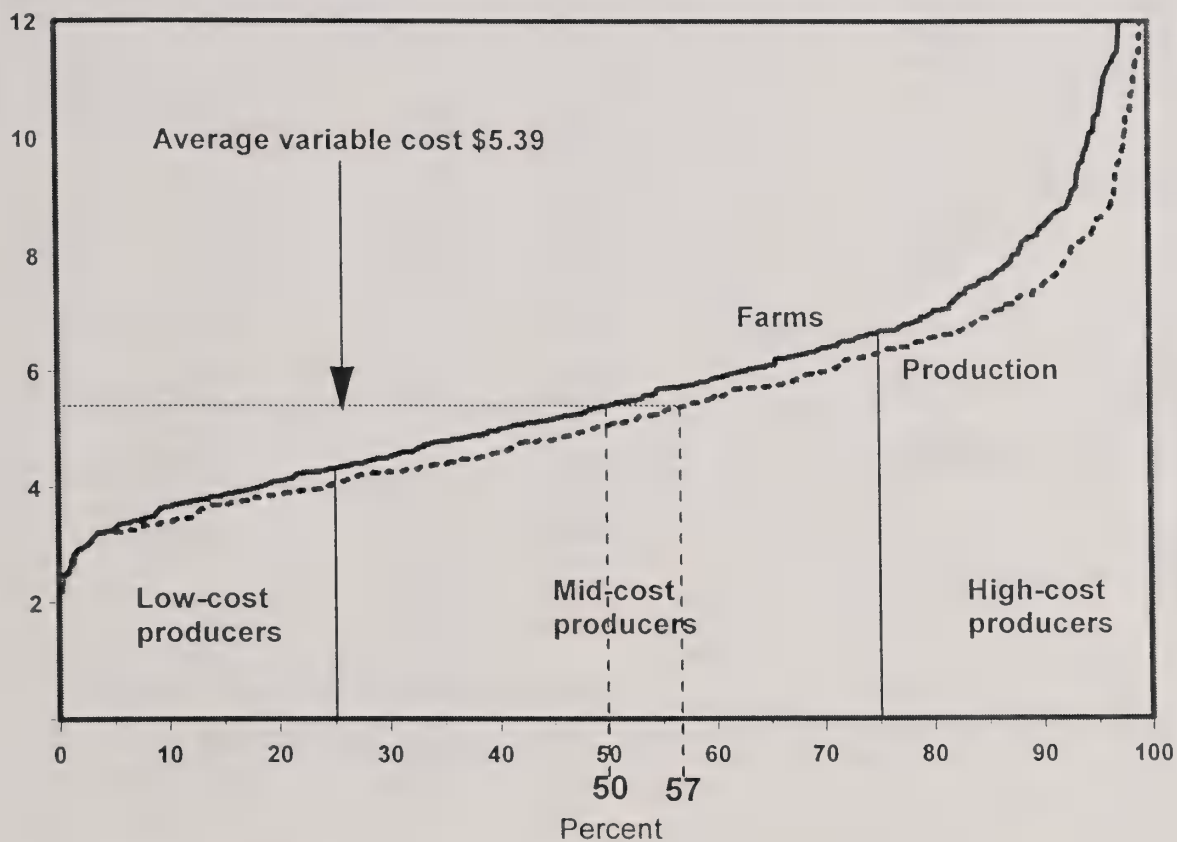
Source: 1992 ARMS Survey

Table 1--Characteristics of rice production operations by region, 1992

Item	Arkansas non-Delta	California	Mississippi River Delta	Gulf Coast	All ARMS[1] farms
Number of farms	3,731	1,299	2,355	2,356	9,722
Percent of ARMS farms	38.19	13.36	24.22	24.34	100.00
Percent of acreage	34.22	12.45	24.41	28.91	100.00
Percent of production	33.18	18.19	22.83	25.80	100.00
Operated acres	923	907	1,648	1,294	1,186
Acres planted to rice	290.23	301.84	326.45	386.29	323.83
Actual yield (cwt)	56.88	85.72	54.85	52.36	58.67
Expected yield (cwt)	58.77	80.72	58.82	58.81	61.53
Variable production costs per planted acre	291.90	449.10	277.87	319.60	316.05
Value of production (dollars):					
Rice	104,010	143,599	113,342	124,740	116,482
Farm	213,230	438,598	401,629	169,482	278,363
Sales class (percent of farms):					
$0-$49,999	9.59	5.78	4.37	6.99	7.19
$50,000-$99,999	7.80	5.82	6.13	20.44	10.19
$100,000-$249,999	42.89	45.29	36.88	49.68	43.40
$250,000-$499,999	32.85	22.38	29.53	16.28	26.61
$500,000 or more	6.87	20.73	23.19	6.61	12.61
Seeding rate-all acres (lbs/ac)	127.17	162.39	124.58	122.90	129.69
Percent of acres reseeded	6.65	1.73	9.28	2.94	5.70
Fertilizers (percent of farms using):					
Nitrogen	100.00	100.00	98.86	100.00	99.72
Phosphorus	28.06	81.74	25.40	94.33	50.65
Potassium	31.38	22.29	18.39	89.00	40.98
Fertilizer application rate (lbs/planted acre):					
Nitrogen	143.84	132.37	165.98	136.85	145.78
Phosphorus	10.75	43.32	6.66	42.74	23.07
Potassium	16.34	8.99	5.37	35.46	18.58
Chemicals (percent of farms using):					
Herbicides	97.07	100.00	99.14	98.17	98.23
Insecticides	4.96	56.12	20.25	38.18	23.55
Herbicide acre-treatments	2.05	1.95	2.61	2.06	2.18
Insecticide acre-treatments	0.06	0.43	0.27	0.60	0.31
Fuel use:					
Diesel (gallons/acre)	45.32	25.77	41.20	37.57	39.54
Gasoline (gallons/acre)	6.03	9.49	5.71	8.67	7.15
LP gas (gallons/acre)	6.24	1.16	14.79	4.40	7.16
Natural gas (1,000 cu. ft/ac)	0.18	0.00	0.08	2.23	0.73
Electricity (kw hours/acre)	2.40	5.00	2.09	1.06	2.26
Financial position (percent of farms):					
Favorable	65.53	64.21	57.21	59.05	61.77
Marginal income	21.29	26.17	15.36	17.69	19.63
Marginal solvency	13.17	7.68	19.97	13.72	14.22
Vulnerable	0.01	1.94	7.46	9.55	4.38

[1] ARMS=Agricultural Resource Management Study.
Source: 1992 ARMS Survey.

Table 2--Rice production costs per acre by variable cash cost group, 1992 (excluding Government payments)

Item	Low-cost producers	Mid-cost producers	High-cost producers	All ARMS[1] farms
	Dollars per planted acre			
Gross value of production	395.68	370.36	334.33	370.74
Total cash expenses	280.14	381.70	513.78	377.66
Variable cash expenses	230.64	318.57	437.78	316.05
Seed	19.84	20.91	21.75	20.76
Fertilizer	35.58	42.31	51.25	42.08
Chemicals	37.87	54.34	69.07	52.33
Custom operations	25.85	42.97	59.50	41.12
Fuel,lubrication, electricity	47.88	60.94	99.47	64.80
Repairs	20.10	26.32	30.40	25.26
Hired labor	21.47	32.01	49.89	32.44
Purchased irrigation water	3.20	9.15	19.51	9.45
Commercial drying	18.85	29.62	36.97	27.83
Fixed cash expenses	49.51	63.13	76.01	61.60
General farm overhead	13.07	22.58	24.57	20.10
Taxes and insurance	16.21	18.30	42.35	18.89
Interest	20.23	22.34	27.09	22.61
Total economic costs	445.59	539.95	667.93	537.23
Variable cash costs	230.64	318.57	437.78	316.05
General farm overhead	13.07	22.58	24.57	20.10
Taxes and insurance	16.21	18.30	24.35	18.89
Capital replacement	45.57	53.79	57.84	52.12
Opportunity costs of owned inputs:				
Operating capital	4.12	5.69	7.81	5.64
Other nonland capital	18.84	20.56	23.05	20.54
Land	96.48	74.20	62.77	78.65
Unpaid labor	20.57	26.24	29.77	25.23
Net returns:				
Value of production less cash expenses	115.54	-11.34	-179.45	-6.92
Value of production less economic costs	-49.81	-169.58	-333.60	-166.49

[1] ARMS=Agricultural Resource Management Study.
Source: 1992 ARMS Survey.

Table 3--Characteristics of rice production operations by variable cash cost group, 1992

Item	Low-cost producers	Mid-cost producers	High-cost producers	All ARMS[1] farms
Number of farms	2,438	4,849	2,436	9,722
Share of ARMS acreage	30.41	49.28	20.32	100
Share of ARMS production	32.44	49.28	18.28	100
Operated acres	1,273	1,163	1,147	1,186
Acres planted to rice	392.68	319.96	262.63	323.83
Actual yield (cwt)	62.60	58.18	52.78	58.67
Expected yield (cwt)	62.43	61.67	59.78	61.53
Variable production costs per planted acre	230.64	318.57	437.78	316.05
Value of production (dollars):				
Rice	150,526	115,072	85,616	116,583
Farm	376,548	267,484	201,743	278,363
Sales class (percent of farms):				
$0-$49,999	5.52	4.67	13.87	7.19
$50,000-$99,999	5.65	11.26	12.63	10.19
$100,000-$249,999	47.71	43.80	38.26	43.40
$250,000-$499,999	23.22	28.90	25.43	26.61
$500,000 or more	17.90	11.37	9.81	12.61
Seeding rate-all acres (lbs/ac)	127.56	132.43	126.23	129.69
Percent of acres reseeded	4.46	6.38	5.90	5.70
Fertilizers (percent of farms using):				
Nitrogen	100.00	100.00	98.90	99.72
Phosphorus	42.33	47.82	64.61	50.65
Potassium	37.29	34.61	57.35	40.98
Fertilizer application rate (lbs/planted acre):				
Nitrogen	137.42	149.55	149.13	145.78
Phosphorus	16.52	22.51	34.30	23.07
Potassium	13.32	17.42	29.29	18.58
Chemicals (percent of farms using):				
Herbicides	96.19	98.78	99.17	98.23
Insecticides	18.33	25.76	24.38	23.55
Herbicide acre-treatments	1.93	2.27	2.33	2.18
Insecticide acre-treatments	0.23	0.31	0.46	0.31
Fuel use:				
Diesel (gallons/acre)	28.45	39.29	57.24	39.64
Gasoline (gallons/acre)	5.72	7.23	9.08	7.15
LP gas (gallons/acre)	5.41	6.91	10.41	7.16
Natural gas (1,000 cu. ft/ac)	0.26	0.56	1.83	0.73
Electricity (kw hours/acre)	2.09	1.80	3.63	2.26
Farms in region:				
Ark. Non-Delta	42.60	42.57	25.03	38.19
California	12.35	14.13	12.84	13.36
Miss. River Delta	25.20	23.72	24.22	24.22
Gulf Coast	19.84	19.58	37.91	24.24
Financial position (percent of farms):				
Favorable	69.60	60.95	55.56	61.77
Marginal income	14.06	19.77	24.93	19.63
Marginal solvency	15.31	14.78	12.02	14.22
Vulnerable	1.03	4.50	7.49	4.38

[1] ARMS=Agricultural Resource Management Study.
Source: 1992 ARMS Survey.

Table 4--Characteristics of rice production operations by size, 1992

| Item | Rice acreage | | | | All ARMS[1] |
	Less than 120	120-249	250-499	500 or more	farms
Number of farms	1,861	2,692	3,617	1,552	9,722
Percent of ARMS farms	19.14	27.69	37.21	15.96	100.00
Percent of acreage	4.55	15.36	40.23	39.85	100.00
Percent of production	4.43	15.24	39.82	40.50	100.00
Operated acres	550	823	1,155	2,653	1,186
Acres planted to rice	77.04	179.66	350.15	808.42	323.83
Actual yield (cwt)	57.07	58.22	58.07	59.63	58.67
Expected yield (cwt)	59.29	61.68	60.85	62.40	61.53
Variable production costs per planted acre	339.78	335.69	317.73	304.06	316.05
Value of production (dollars):					
Rice	26,850	63,937	124,682	296,588	116,583
Farm	138,142	183,364	255,225	665,157	278,363
Sales class (percent of farms):					
$0-$49,999	28.52	5.10	.56	n/a	7.19
$50,000-$99,999	25.55	14.94	3.14	n/a	10.19
$100,000-$249,999	30.85	61.85	49.42	13.35	43.40
$250,000-$499,999	11.79	13.40	38.59	38.42	26.61
$500,000 or more	3.29	4.72	8.29	47.56	12.61
Seeding rate--all acres (lbs/ac)	136.25	132.40	131.51	126.06	129.69
Percent of acres reseeded	5.26	5.16	5.61	6.06	5.70
Fertilizers (percent of farms using):					
Nitrogen	99.28	99.50	100.00	100.00	99.72
Phosphorus	45.55	53.22	50.36	52.96	50.65
Potassium	31.87	37.57	47.12	43.51	40.98
Fertilizer application rate (lbs/planted acre):					
Nitrogen	137.78	142.02	146.01	147.88	145.78
Phosphorus	21.21	24.20	23.55	22.37	23.07
Potassium	12.86	13.98	22.42	17.11	18.58
Chemicals (percent of farms using):					
Herbicides	96.41	97.65	99.83	100.00	98.23
Insecticides	9.33	24.91	25.60	33.46	23.55
Herbicide acre-treatments	1.99	1.96	2.11	2.35	2.18
Insecticide acre-treatments	0.11	0.29	0.29	0.37	0.31
Fuel use:					
Diesel (gallons/acre)	47.10	42.27	41.43	35.88	39.64
Gasoline (gallons/acre)	10.30	7.97	7.07	6.54	7.15
LP gas (gallons/acre)	15.17	5.33	5.39	8.75	7.16
Natural gas (1,000 cu. ft/ac)	0.37	0.60	0.63	0.91	0.73
Electricity (kw hours/acre)	3.02	2.45	2.87	1.48	2.26
Farms in region:					
Arkansas non-Delta	46.60	31.71	40.98	32.81	38.19
California	15.14	16.43	11.35	10.60	13.36
Mississippi River Delta	10.51	23.68	29.09	32.67	24.24
Gulf Coast	27.75	28.18	18.58	23.92	24.21
Financial position (percent of farms):					
Favorable	66.05	60.76	61.90	58.09	61.77
Marginal income	19.17	23.51	17.52	18.39	19.63
Marginal solvency	12.17	9.74	17.67	16.40	14.22
Vulnerable	2.61	6.00	2.91	7.12	4.38

[1] ARMS=Agricultural Resource Management Study.
n/a=Not available.
Source: 1992 ARMS Survey.

Table 5--Regression estimates and contribution of factors to unit cost variation

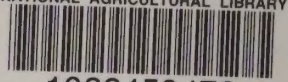| Variable	Coefficient	T-statistic	Variance effect	Percent of variance effect
Organizational characteristics:				
Size (rice acres planted)	-0.001772	-1.402	0.235836	3.67
Size squared (rice acres planted squared)	0.000001	1.152	0.078203	1.22
Percent rice prodn/total prodn value	0.003752	.615	0.011366	0.18
Rotation (no rotation for 1990-92)	0.130437	.384	0.002737	0.04
Depreciation claimed/total prodn value	0.088976	16.860***	4.824953	75.18
Land tenure (% of rice acres share-rented)	0.017724	3.901***	0.625443	9.75
Land tenure (% of rice acres cash-rented)	0.010879	2.827***	0.177351	2.76
Inches water appl/cwt of rice produced	1.569557	2.083**	0.194882	3.04
Grain moisture percentage level at harvest	0.138451	2.369**	0.213855	3.33
Operator characteristics:				
Education (1=high school grad; 0=otherwise)	-0.480730	-0.797	0.053017	0.83
Education (1=college grad; 0=otherwise)	-0.020157	-0.032	0.000078	0.00

F=39.16 R^2=0.38
*** Statistically significant at the 99-percent confidence level.
** Statistically significant at the 95-percent confidence level.